

**EVALUATION AND COMMENTS
RELATED TO PROPOSED
IMPROVEMENTS TO THE ILLR
PREDICTION MODEL,
ET DOCKET NO. 00-11**

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BACKGROUND

The FCC has released a Notice of Proposed Rule Making (NPRM)¹ prescribing a point-to-point predictive computer model for determining the ability of individual locations to receive an over-the-air television broadcast signal. In its Report and Order in CS Docket No. 98-201, the Commission endorsed the use of a specific model for the prediction of signal strength at individual locations. This model was called the Individual Location Longley- Rice (ILLR) model by the Commission, and is a version of Longley-Rice 1.2.2. Based on a earlier proceeding, the Commission found that vegetation and buildings affect signal intensity at individual locations, however it also found that there was no standard means of including such information in the ILLR that had been accepted by the technical and scientific community. The Commission therefore stated that land use and land cover information will be included in the ILLR when an appropriate method for using such information has been developed and accepted.

In the NPRM associated with ET Docket 00-11, the FCC proposes to improve the ILLR model by adding clutter loss parameters. Reception point parameters are to be classified based upon the environment of the individual household reception point. Reception point parameters are to be classified in terms of codes used in the Land Use and Land Cover (LULC) database of the United States Geological Survey (USGS). To simplify the use of the database for ILLR purposes, the LULC categories have been reorganized in a way specifically relevant to radio propagation. After regrouping, 10 environmental classes were identified.

¹ FCC Notice of Proposed Rule Making, In the Matter of Establishment of an Improved Model for Predicting the Broadcast Television Field Strength Received at Individual Locations, ET Docket No. 00-11, January 20, 2000.

In the proposed ILLR model it is contemplated that a clutter loss value will be associated with every regrouped LULC classification. However, the available data for assigning values to these parameters is limited. The Commission proposes to base the ILLR table of clutter loss on the results published in a recent engineering journal paper by Thomas N. Rubinstein.² The Rubinstein values of clutter loss are allegedly derived from measurements made at receiver sites with Fresnel zone clearance, hence the Commission states that the values should be applied in the model in matching conditions. For other situations, the clutter loss will be zero. The Commission has requested comments on whether other data are available to allow clutter loss to be extended to other situations, and whether there are other approaches that could be integrated into ILLR to take into account losses due to vegetation and man-made structures.

Another limitation of the Rubinstein table of clutter loss is that data is not available for VHF television channels 2 through 6, so that clutter loss cannot be assigned without introducing an exception to the Commission's stated rule of not assigning values unless measurement data are available for matching situations. The Commission proposes to address this issue by using clutter loss values for high-band VHF that have been derived utilizing a frequency trend analysis similar to the Okumura method. The Commission has also requested comments on the acceptability of this exception and approach.

APPROACH

IITRI obtained and reviewed the FCC NPRM, available USGS LULC³ and ILLR documentation, the Rubinstein paper, and additional materials related to the Longley-Rice model and radio propagation.⁴ Based on the cited materials and our engineering experience

² Rubinstein, Thomas, N., Clutter Losses and Environmental Noise Characteristics Associated with Various LULC Categories, IEEE Transactions on Broadcasting, Vol. 44, No. 3, September 1998.

³ USGS Land Use and Land Cover Data, Condensed User Guide (Global Land Information System HTML), US Geological Survey, Reston, VA, 1999.

⁴ Longley, Anita, G., Radio Propagation In Urban Areas, 28th IEEE Vehicular Conference, Denver, CO, March 1978, pp. 503-511.

and judgement, IITRI provides comments on the following technical areas associated with the use and implementation of LULC categories and clutter loss values in the ILLR model:

1.) The use of the Rubinstein measurement method and results for assigning clutter loss values for use in ILLR:

- Differences in measurements and television antenna heights, type and characteristics
- The use of the Okumura model for signal strength prediction
- Limited representation of geographical and climate areas in the measurement sample

2.) The utilization of USGS LULC database for clutter modeling:

- The appropriateness of grouping the 37 USGS LULC categories into 10 categories for use in the ILLR model
- The age of the LULC database
- The LULC spatial resolution

3.) The application of the Rubinstein results to create clutter loss factors:

- The acceptability of extrapolating L-VHF values from H-VHF results, and the method used to do so
- Shadow region impacts
- Consideration of clutter in the existing ILLR model

4.) General comments:

- Treatment of Longley-Rice error codes
- Use of appropriate surface refractivity value instead of median value
- Alternate formulation of Longley Urban Factor with Hata height gain factors

1.) COMMENTS ON THE RUBINSTEIN PAPER

Rubinstein recognized the need for a more accurate characterization of clutter loss and environmental noise. His paper describes a series of tests that were performed to quantify the effects of ground clutter on RF propagation path loss. Tests were conducted at 162, 460, and 860 MHz in four different localities in the United States.

The methodology and results reported by Rubinstein are fine for a research paper and may form the basis for a larger effort to collect data that can be used to define a “clutter loss” fudge factor for ILLR. However, as the sole basis for modifying the methodology used to determine Grade B television coverage, there are several serious methodological issues that need to be considered if the Rubinstein results are to be used to define clutter loss values.

The methodology used by Rubinstein to collect the data presented in the paper consisted of a mobile vehicle with several vertically polarized omnidirectional antennas on the roof, which is directly applicable to mobile communications applications rather than broadcast television. The antenna height and type differences between mobile radio and broadcast television, the statistically insignificant number of measured data points and geographical and climate areas, and the use of the Okumura model for signal strength prediction form the basis for several comments related to the application of the Rubinstein results to defining clutter loss values.

Differences Between the Measurements and Broadcast Television Antennas

Several antenna related factors will result in differences between the Rubinstein measurements and those for broadcast paths. The Rubinstein measurements were made from a moving vehicle in city streets that, necessarily, used a vertically polarized short antenna (probably a monopole). For FCC applications of the ILLR, the receiving antennas will be significantly different. The FCC proposes to use the model with antennas at heights of 6 or 9 m, depending on the rooftop height. Furthermore, the TV antennas will be fixed, horizontally polarized, and directional.

Another factor affecting the applicability of the measurements is the assertion that the paths are unobstructed by terrain, i.e., the Fresnel zone clearance is at least 0.6. For mobile situations where the antenna height is only 3 m or less this will often not be the case. Also, the height of the broadcast transmitter antenna, which is generally significantly higher than a mobile base station, is a factor that must be taken into account. These differences will affect the added clutter losses and, in general, it would be expected that clutter losses measured by a low omnidirectional antenna would significantly exceed those seen by a TV antenna. The TV antenna would be above many of the obstacles that cause multipath clutter to appear in the lower antenna. Also, the directional antenna will discriminate against most of the clutter sources that affect the omnidirectional antenna.

The difference in receiver antenna height can be accounted for by adjusting the measured clutter loss values with a height gain factor. Reference 4 presents data that can be used to obtain this factor for adjusting the Rubinstein clutter losses. The values, obtained from Reference 4 and presented in Table 1, are approximate since the specific LULC clutter categories were not addressed in Reference 4. The median height gain when the receiving antenna is raised from 3 m to 10 m depends on the frequency.

TABLE 1 RECEIVING ANTENNA HEIGHT GAIN SUMMARY (BASED ON REFERENCE 4)			
Frequency Range (MHz)		Terrain/Land Features	Height Gain 3-10 m (dB)
Low VHF	40-100	Rural/Urban	9-10
High VHF	150-250	Urban/Hilly	10-11
		Flat	7
UHF	450-1000	Urban	14
		Suburban	6-7
		Flat to Hilly	10 to 0

Hata has also developed relationships for height gain factors.⁵ Factors for height gain from the Hata paper are presented in Table 2. The values are the reduction in loss resulting from an increase in receiver antenna height from 3 m to 6 m and 9 m for each of the frequency bands shown in Table 1. Values are also shown for two urban areas, one representing a medium-small city and the other a large city.

TABLE 2 RECEIVING ANTENNA HEIGHT GAIN SUMMARY (BASED ON REFERENCE 5 CURVES)			
Frequency Range	Terrain/Land Features	Height Gain (dB)	
		3-6 m	3-9 m
Low VHF 100 MHz	Large City	4	7
	Medium-Small City	4	10
High VHF 200 MHz	Large City	4	7
	Medium-Small City	6	12
UHF 700 MHz	Large City	2	3
	Medium-Small City	8	15

The Rubinstein measurements were made using vertical polarization, whereas television signals are horizontally polarized. This difference will result in clutter losses greater than would be appropriate for horizontal polarization. In street canyons, where the surrounding building walls are predominantly vertical, building reflection coefficients for vertically-polarized waves will exceed those for horizontally-polarized waves. This effect would cause the measured clutter to be greater than what would be expected for horizontally-polarized TV signals. Therefore, TV antennas located on the lower rooftops of buildings surrounded by higher ones may be subjected to less clutter than measured by Rubinstein. Also, in residential areas, where tall tree trunks may surround the houses, the absorption for vertically-polarized waves would exceed that for horizontally-polarized waves and, again, the Rubinstein clutter value would likely be excessive for the horizontally-polarized waves. According to Reference 4, given a clear path to the transmitter site, the polarization discrimination at rooftop level in an urban area has a 90% value

⁵ Hata, Masaharu, Empirical Formula for Propagation Loss in Land Mobile Radio Services, IEEE Transactions on Vehicular Technology, VT-29, No. 3, August 1980.

of 9 dB. Since not all antennas will be in the clear an appropriate adjustment of approximately 5 dB must be applied to account for polarization discrimination.

The Rubinstein measurements were allegedly taken for paths having first Fresnel zone clearance of 0.6, in other words, paths unobstructed by terrain. For a mobile receiver with an antenna height of 3 m in a somewhat hilly area, a clear path is difficult to achieve for most path lengths. In order to correctly apply the Rubinstein clutter losses to broadcast propagation paths, the values must be adjusted to remove the effect of terrain obstruction. A loss adjustment of 4 dB is appropriate to correctly apply the measured data to an unobstructed broadcast path. (Further discussion of first Fresnel zone clearance effects is provided below.)

Broadcast transmitting antennas are generally much higher than antennas used for mobile base stations. This will result in a height gain such as that taken into account for the receiver. Hata (Reference 5) provides data, as a function of path length and transmitting antenna height, which can be used to adjust the clutter loss to account for the increased height of TV broadcast antennas. For a transmitter antenna height of 400 m and path length of 60 km the adjustment to clutter loss is 13.6 dB.

The Rubinstein clutter loss values presented in Reference 2 must be adjusted by the factors presented in the previous paragraphs to be applicable to broadcast. These adjustments are summarized below:

- Receiving Antenna Height Gain – depends on local land features and frequency (Tables 1 and 2)
- Polarization – reduce clutter loss by 5 dB
- Fresnel Zone Clearance – reduce clutter loss by 4 dB
- Transmitting Antenna Height Gain – adjustment based on Hata's relationships - reduce clutter loss by 13.6 dB typically

Applying these adjustments to the Rubinstein values reduces the clutter loss requirement to 0 dB for all cases. This is not unexpected due to the deficiencies of the Rubinstein measurement methodology for collecting clutter loss data that is applicable to television broadcast applications.

First Fresnel Zone Clearance Effects

An important concept in analyzing propagation effects, particularly those associated with diffraction and reflection, and the effects of terrain and obstructions such as clutter, is that of the Fresnel zone. The first Fresnel zone radius is used to measure path clearances in terms of their effect at the frequency in question. The first Fresnel zone is the surface containing every point for which the sum of the distances from any reflection point to the two ends of the path is exactly one-half wavelength longer than the direct end-to-end path. It is important to note that clearance requirements expressed in Fresnel zone terms apply to the sides and above, as well as, below the path.

For illustrative purposes it can be shown that a first Fresnel zone clearance of 0.6 corresponds to adequate path clearance such that there is no additional path loss from free-space due to grazing effects⁶. For Fresnel zone clearances less than 0.6, there is increasing loss due to grazing and shadowing of obstructions, until the clearance equals 0 or less in which case the path is considered to be obstructed and diffraction effects determine the path loss. For propagation paths of average roughness, the loss attributable to grazing at Fresnel zone clearance of 0.6 is 0, 0.3 clearance is approximately 4 dB, and 0 clearance is 10 dB.

If the measured data did not have first Fresnel zone clearance, as appears to be the case, then the reported results attributed to clutter loss should be reduced by an appropriate amount to account for Fresnel grazing loss.

Use of Okumura for Signal Strength Predictions

Rubinstein's method of calculating the clutter loss values for various LULC regions was first to use the Okumura urban model and add an open area factor to predict the signal strength that should occur without clutter. The measured signal strength data were subtracted from these predictions to arrive at the clutter loss. Since the ILLR model will be used to make service predictions, not the Okumura model, there is no assurance that an equivalent difference would apply. This approach is like saying , $A - C = B - C$, where $A \neq B$. A more viable approach is to make the signal strength predictions with the ILLR model and find the difference between its predictions and appropriate signal strength measurements. The measurements should be made in conditions similar to those in which the coverage model will be used, i.e. with antenna heights of 6 and 9 m and with horizontal polarization. It is not feasible to incorporate the effects of antenna directionality in the measurements because these effects are so dependent upon the distribution of scattering sources in the near vicinity of each antenna.

Limited Geographical/Climate Areas and Sample Size in Survey

The Rubinstein measurements were taken for three frequencies (162, 460 and 860 MHz) at four localities in three geographical areas: 1) urban southern California (Los Angeles and San Diego), 2) rural/suburban NW Washington State (Whatcom County), and 3) urban Atlanta. It was necessary to discard portions of the resulting data for various reasons, such as unexpected trends and insufficient sample size, resulting in limited representation of the measurement areas. Of the possible 216 data sets (category, location, and frequency) only 38 were determined to be valid. This resulted in 12 of the original 24 categories remaining to be mapped into the 10 ILLR Clutter Categories. It is questionable as to whether the location representation is sufficiently representative of all climate and vegetation types found in the United States. Areas such as arid/desert (Las Vegas or Phoenix), NE deciduous areas (Boston or Buffalo), SE scrub pine, (Orlando), hilly (Pittsburgh), mountainous (Denver), Great Plains (Des Moines), southern semi-tropical (New Orleans, Miami,

⁶ Engineering Considerations for Microwave Communications Systems, GTE Lenkurt Incorporated, June 1970.

Houston) will not be properly represented since these areas have far different terrain and foliage characteristics than the three areas surveyed. In order to provide sufficient data for each category, locations that more accurately represent the LULC categories should be surveyed ensuring that a statistically significant sample size is available for each.

Weather, Time-of-Day, Time-of-Year

There was no weather, time-of-day, or time-of-year information provided for any of the data. For low VHF channels in coastal areas time-of-day and weather is important, and time-of-year and weather is important for areas that have deciduous or pine trees.

2.) COMMENTS ON THE LAND USE LAND COVER DATABASE

The USGS land use and land cover (LULC) data files describe the vegetation, water, natural surface, and cultural features on the land surface. The USGS provides these data sets as part of its National Mapping Program. The LULC data are derived from thematic overlays registered to 1:250,000-scale base maps and a limited number of 1:100,000-scale base maps. LULC data provides information on urban or built up land, agricultural land, rangeland, forest land, water, wetlands, barren land, tundra, and perennial snow or ice. LULC data is available for the conterminous United States and Hawaii.

Due to the geographic and mapping origin of the LULC, several issues related to its application to radio propagation, and specifically clutter loss determination are discussed below. These issues are concerned with the aggregation of the 37 first and second order LULC classification codes into 10, the age of the present LULC database, and the spatial resolution of the database.

Aggregation of Classification Codes

The LULC database was originally intended for geography and mapping purposes. As such, all of the categories reported (37) are not necessarily required for propagation prediction

purposes. The aggregation of the 37 categories into fewer propagation significant categories looks reasonable and simplifies the database. In fact, one commercial radio propagation model supplier, EDX Engineering, has already aggregated the 37 categories into 10 for their Signal Pro model implementation, and has assigned loss values versus frequency to each category.

A suggested improvement to the definition of the 10 proposed categories is to split the Forest Land category into two or more categories (5a and 5b) to account for deciduous and evergreen forest types. Since one of the purposes of the clutter loss is to account for foliage effects, and there is a distinct difference between deciduous forests commonly found in the northeast United States, and evergreen forests in the northwest, and to a lesser degree in the southeast, it may make sense to consider utilizing different forest types in any consideration of clutter loss factors.

Age of LULC Database

Manual interpretation of aerial photographs acquired from NASA high-altitude missions and other sources were first used to compile the LULC maps. Secondary sources from earlier land use maps and field surveys were also incorporated into the LULC maps as necessary. At a later time, the LULC maps were digitized to create the LULC database. The classification codes used to describe natural and man-made features are based on work by Anderson et al. in 1976.⁷

The data and classification scheme utilized in the LULC database is in excess of 20 years old now, and for this reason, much of the data in urban regions is suspect due to development of housing and industrial areas in all major metropolitan areas. A Table presenting the growth of the 25 fastest growing Metropolitan Statistical Areas (MSAs), and Primary MSAs is shown as Table 3. Also, the approximately 20% growth of the United

⁷ Anderson, J. R., Hardy, E. E., Roach, J. T. and Witmer, R. E., 1976, A Land Use and Land Cover Classification System for Use with Remote Sensor Data, U.S. Geological Survey, Professional Paper 964, p 28, Reston, VA.

States in general over the past 20 years (224 million in 1980 vs 270 million in 2000) leads to the realization that the residential, commercial, and agricultural categories for all MSAs described in the LULC are out of date. For this reason, an updated LULC database is recommended before it is applied for the purpose of radio propagation clutter prediction.

LULC Spatial Resolution

The minimum area representing the man-made features of the LULC polygons are 10 acres that have a minimum width of 200 m. Non-urban and non-man-made features may be mapped with polygons with a minimal area of 40 acres that have a minimum width of 400 m.

The relatively large size of these polygons with respect to many types of residential and commercial developments may cause errors in cases where one category changes to another (border areas), or near water, wetlands or otherwise reported unpopulated areas. The higher the population density, the greater the error.

TABLE 3
25 OF THE FASTEST GROWING MSAs AND PMSAs
DURING THE PERIOD 1980-1998

MSA or PMSA	1980 Population ^a	1990 Population ^a	1998 Population ^b	% Increase
Naples, FL MSA	85,971	152,099	199,436	132
Riverside-San Bernardino, CA PMSA	1,558,215	2,588,793	3,114,072	99.8
Fort Pierce, FL MSA	151,196	251,071	295,118	95
Fort Myers-Cape Coral, FL MSA	205,266	335,113	392,895	91.4
Las Vegas, NV MSA	463,087	741,459	1,321,546	185
Ocala, FL MSA	122,488	194,833	241,513	97.1
Orlando, FL MSA	699,904	1,072,748	1,504,569	115
West Palm Beach-Boca Raton, FL SA	576,812	863,518	1,032,625	79
Melbourne-Palm Bay, FL MSA	212,959	398,978	466,093	119
Austin, TX MSA	536,674	781,572	1,105,909	106
Daytona Beach, FL MSA	258,762	370,712	470,864	82
Atlanta, GA MSA	2,138,136	2,835,511	3,746,059	75.2
Las Cruces, NM MSA	96,340	135,510	169,165	75.6
Phoenix, AZ MSA	1,509,175	2,122,101	2,931,004	94.2
Yuma, AZ MSA	76,205	106,895	132,259	73.6
Modesto, CA MSA	265,900	370,522	426,460	60.4
Stockton, CA MSA	347,342	480,628	550,445	58.5
Sarasota-Bradenton, FL MSA	202,251	277,776	543,082	168
Fort Worth-Arlington, TX PMSA	973,138	1,332,053	1,592,577	63.6
McAllen-Edinburg-Mission, TX MSA	283,323	383,545	522,204	84.3
Vallejo-Fairfield-Napa, CA PMSA	334,402	451,186	496,703	48.5
Bakersfield, CA MSA	403,089	543,477	631,459	56.6
Sacramento, CA MSA	1,099,814	1,481,102	1,685,812	53.3
San Diego, CA MSA	1,861,846	2,498,016	2,780,592	49.3
Laredo, TX MSA	99,258	133,239	188,166	89.6

^aRand McNally Commercial Atlas & Marketing Guide, 1996, 127th edition.

^b US Census Bureau, Metropolitan Area Population Estimates for July 1, 1998, December 1999.

3.) APPLICATION OF RUBINSTEIN RESULTS TO ILLR TO CREATE “CLUTTER LOSS” FACTOR

The semi-empirical Longley-Rice radio propagation prediction model has been used by the FCC for many years to estimate the coverage of broadcast television stations for DTV planning purposes. Long experience by engineers has shown that the model performs well in situations where buildings or trees are not present, and also very well when trees and buildings are present. The FCC proposes to extend the model by incorporating the effect of losses introduced by these obstacles. The proposal would add a clutter loss to the loss value predicted by the Individual Location Longley-Rice (ILLR) model. This added loss would be assigned based upon the clutter environment in which the reception point is located. The clutter environment would be determined by classification codes used in the Land Use and Land Cover (LULC) database of the United States Geological Survey. The LULC database is simply a descriptive one that incorporates no quantitative information about the height, spacing, orientation or density of buildings or trees. The LULC database would be further simplified by combining the 37 categories into 10 environmental classes that have similar characteristics for radio propagation. The clutter loss value to be assigned to each of these 10 classes would be based upon measured data published in a journal article by Thomas N. Rubinstein.

The FCC has acknowledged two difficulties in the Rubinstein measured data. First, no measurements were made for locations that were “shadowed”, defined as having a geometrical parameter v less than 0.778. The dimensionless parameter v is commonly used to calculate knife-edge diffraction loss using Fresnel integrals. Second, the Rubinstein measurements do not cover frequencies used by low-band VHF television stations, channels 2-6. In fact, there are other areas of concern. One is that the measurements were taken from a moving vehicle on the street. Although the paper does not specify the antenna heights, it may be presumed that the vehicular antenna height was considerably lower than either the 6 m height for one-story buildings or the 9 m height for taller buildings that will be applied in using the ILLR and

probably on the order of 2-3 m. Of even greater concern is the fact that the signal strength difference measurements (the clutter loss values) were obtained by subtracting the measured signal strength data from signal strength predictions made by using the Okumura empirical model. The latter model consists of a series of curves suitable for estimating field strength in urban, suburban, or open areas at frequencies from 150 to 1500 MHz.

If the Rubinstein results will be used to form the basis for a Clutter Loss Factor, then the numbers that were proposed in the NPRM should be modified to take into account the differences in antenna types and antenna characteristics, and antenna heights used in the measurements and commonly used for television receivers.

Other computer models exist that address the clutter loss issue such as EDX Engineering Signal Pro. As a point of comparison, the clutter categories and associated clutter loss values used in Signal Pro are shown in Table 4. While it is not known how the clutter loss values in Table 4 were derived, and it is unknown if they are appropriate for use in ILLR, it can be seen that the values shown are much lower than those in Table 3 of the NPRM presented by the Commission.

TABLE 4 EDX ENGINEERING CLUTTER LOSS VALUES				
LULC Category	Frequency (MHz)			
	50-100	100-200	200-500	500-1000
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	3.0	5.0	7.0	10.0
6	5.0	7.0	10.0	12.0
7	6.0	9.0	12.0	15.0
8	3.0	5.0	7.0	10.0
9	5.0	7.0	10.0	12.0
10	0	0	0	0

EDX LULC Categories:

- 1 open land
- 2 agricultural
- 3 rangeland
- 4 water
- 5 forest
- 6 wetland
- 7 residential
- 8 mixed urban/ buildings
- 9 commercial/industrial
- 10 snow & ice

Low-Band VHF Clutter Loss Values

The lowest frequency used by Rubinstein to measure clutter values was 162 MHz. This is 3 octaves above the channel 2 frequency of 54-60 MHz. Therefore clutter losses measured at 162 MHz were not considered to be appropriate for the low VHF channels. Thus, the FCC proposes using clutter values for these lower frequencies that are extrapolated from Rubinstein's values for the high-band VHF channels. The frequency trend used was taken from Okumura's curves. But the Okumura curves apply to field-strength data not clutter data.

Shadowed Regions

The Rubinstein paper refers to using terrain data in the evaluation but does not explicitly say how the data were used. It does state that the Okumura model was used to predict the signal strength in open areas. However, since the Okumura model does not require terrain data, it must be presumed that those data were used solely to compute the geometrical parameter v , whose value defines the shadowed regions. Because the calculation of shadow loss was considered to be unreliable, no such locations were allegedly included in the data that determine the clutter loss values. For this reason, the FCC proposes to add the clutter loss to the ILLR-predicted path loss only when it has been determined that the ray clearance is at least 0.6 times the radius of the first Fresnel zone. A ray clearance of 0.6 Fresnel zones is approximately equivalent to Rubinstein's geometrical parameter v less than 0.778. The proposal doesn't state how this determination is to be made. The ILLR does not provide information about Fresnel clearance ratios. In addition, it is questionable whether Rubinstein actually had first Fresnel zone clearance at most receive sites.

4.) GENERAL COMMENTS

Correction of Errors in NPRM Related to ILLR Input Parameters and Appendix A Field Calculation.

- Paragraph 12: should read channels 2 through 6
- Appendix A: Table 1 XI value should be 0.1 km vis 0.1m
- Appendix A: Methodology for determining Field. No units are specified for the variables in the formula, which makes it difficult to reproduce the 106.92 constant.

Treatment of L-R Error Codes

In Appendix A of the Notice, there is a statement that “where error codes indicate a severe error, the field strength is deemed inadequate for TV service.” Further information provided in Appendix A, Table 1 for parameter type KWX states that the field strength prediction should be accepted when KWX equals 0 or 1, and otherwise presume the field is inadequate for TV reception.

The error codes that the ILLR model can return are as follows:

KWX=0:	no error
KWX=1:	frequency slightly out of range height above ground not between 1-1000 meters distance greater than 1000000 meters
KWX=2:	climate code out of range mode of variability out of range
KWX=3:	distance less than dmin

KWX=4: wave number [frequency] grossly out of range
 height above ground not between 0.5-3000 meters
 distance not between 1000-2000000 meters
 take-off angles out of range
 ENS [surface refractivity] out of range
 GME [earth's effective curvature] out of range

For KWX=2, because the mode of variability should be set to 1 and because the climate code can only be out of range if set incorrectly by the user, any calculation in which KWX=2 is returned should be re-run. There is no reason whatsoever to presume a lack of service, as the *Notice* proposes.

Apparently, KWX =3 is returned when the path length is smaller than a calculated value defined as d_{min} . This would imply a very short path length, and a minimum value of predicted propagation path loss. If this is the case, then there is no reason to assume a lack of service when in fact this may be a region very close to the transmitter where the signal level is very high.

Similarly, KWX=4 is likely to be returned only if the parameters are incorrectly set by the user. If the returned value is not to be accepted, then the computation should be re-run with proper input parameters. The principal exception in the case of KWX=4 is for receiving sites less than 1 kilometer from the transmitting antenna. These sites will have the error code returned, yet in virtually all cases the receiving site will receive a signal intensity far above city-grade service, let alone Grade B service. If the reason that KWX=4 is returned is that the distance is out of range, then the value returned should be accepted.

Utilize Appropriate Surface Refractivity Instead of Median Value

The radio refractive index of air is a function of atmospheric pressure, temperature, and humidity. The term "4/3 Earth" refers to a surface refractivity value of 301, and an effective Earth radius of 5280 statute miles or 4/3 of the actual Earth radius. The median value of surface refractivity (N_s) is different for various climate and geographic regions. Short term

variations (monthly or daily) in the values of surface refractivity are usually smaller in high dry climates and greater in low, humid areas.

If clutter will be considered in ILLR, and a database of clutter factors will be created, we should take the opportunity to also use realistic values for surface refractivity. A database of N_s should be created for use in the model. An example of N_s values for several major metropolitan areas is provided in Table 5

TABLE 5 MEDIAN VALUES OF SURFACE REFRACTIVITY (N_s) FOR SEVERAL METROPOLITAN AREAS	
Metropolitan Area	Median N_s
Miami, FL	365
Charleston, SC	341
Houston, TX	367
Chicago, IL	314
Pittsburgh, PA	307
Buffalo, NY	311
Washington, DC	320
Philadelphia, PA	327
Denver, CO	257
Los Angeles, CA	335
Tucson, AZ	277

Consideration of Clutter in Existing ILLR Model.

The ILLR is a semi-empirical model developed with some consideration of measured data and therefore includes certain effects of clutter.^{8,9} The model should be investigated, and

⁸ M.M. Weiner, Use of the Longley-Rice and Johnson-Gierhart Tropospheric Radio Propagation Programs: 0.02-20 GHz, 4 IEEE Journal on Selected Areas in Communications 297 (Mar. 1986), 298.

⁹ M.L. Meeks, VHF Propagation over Hilly, Forested Terrain, 31 IEEE Transactions on Antennas and Propagation 483 (May 1983), 488.

appropriate adjustments implemented into the process to ensure that clutter loss is not overestimated.

Alternate Formulation of Longley Urban Factor with Hata Height Gain Factors

An alternative methodology for determining correction factors for ILLR utilizes the Longley “Urban Factor” (UF) formulation (Reference 4), with appropriate corrections for television specific transmitter and receiver antenna heights (height-gain factors).

The Longley UF formula was originally presented as the difference in predicted values between the Longley-Rice model and empirical curves presented by Okumura for an urban area. Both models utilized transmitting antenna heights of 3 m and 200 m for the receiver and transmitter respectively. As expected, the urban curves presented by Okumura show greater attenuation. The difference between the two models may be considered as representing the additional power loss in an urban area, and is referred to as an urban factor. The UF increases with increasing frequency and decreases with increasing distance from the transmitter. The resulting formula is presented as Equation 1.

$$UF = 16.5 + 15\log(f_c/100) - 0.12d \quad \text{Eq 1.}$$

Where: f_c = frequency (MHz)
 d = distance from transmitter (km)

Since the television household receiving antennas and broadcast towers are found at antennas heights different than the 3m and 200m used to formulate the UF, a consideration of the receiver and transmitter height gain can be applied to the UF to illustrate its application to the television specific case.

From Hata (Reference 5), a formula for transmitter height gain is presented in terms of transmitter antenna height and distance from the transmitter (Equation 2).

$$A(h_b) = -13.82 * \log_{10} h_b + (44.9 - 6.55 * \log_{10} h_b) * \log_{10} R \quad \text{Eq. 2}$$

where: R = distance from the transmitting antenna (km)
 h_b = transmitter antenna height (m)

Hata's receiver antenna height gain correction factors are expressed as follows for a medium-small city and large city respectively (Equations 3, 4, and 5):

Correction factor for receiving antenna height gain, medium-small city:

$$a(h_m) = (1.1 * \log_{10} f_c - 0.7) * h_m - (1.56 * \log_{10} f_c - 0.8) \quad \text{Eq. 3}$$

Correction factor for receiving antenna height gain, large city:

$$a(h_m) = 8.29 * (\log_{10} 1.54 h_m)^2 - 1.1 \quad \text{for } f_c \leq 200 \text{ MHz} \quad \text{Eq. 4}$$

$$a(h_m) = 3.2 * (\log_{10} 11.75 h_m)^2 - 4.97 \quad \text{for } f_c \leq 400 \text{ MHz} \quad \text{Eq. 5}$$

where: h_m = receiver antenna height (m)

If these Hata derived factors are combined with the Longley UF, a formulation results where the difference in receiver and transmitter antenna heights are considered. UF losses for frequencies between 66 MHz (TV channel 4), and 760 MHz (TV channel 60), receiver antenna heights of 6 m and 9 m, and transmitter antenna heights of 300 m and 500 m are provided in Tables 6 and 7 for a small-medium city. Similar results can be produced for a large city.

TABLE 6 URBAN FACTOR WITH HATA HEIGHT GAIN CONSIDERATIONS Transmitter Antenna Height 300 m Receiver Antenna Heights 6 m/9 m							
D (km)	66 MHz	100 MHz	150 MHz	200 MHz	300 MHz	500 MHz	760 MHz
10	5.1/1.2	7.2/2.7	9.3/4.2	10.7/5.2	12.8/6.7	15.4/8.6	17.4/10.0
20	3.5/-0.4	5.6/1.1	7.7/2.6	9.2/3.7	11.2/5.2	13.8/7.0	15.9/8.5
30	2.1/-1.8	4.2/-0.3	6.3/1.2	7.8/2.3	9.8/3.7	12.4/5.6	14.5/7.1
40	0.8/-3.1	2.9/-1.6	5.0/-0.1	6.4/0.9	8.5/2.4	11.1/4.3	13.1/5.7
50	-0.5/-4.4	1.6/-2.9	3.6/-1.4	5.1/-0.4	7.2/1.1	9.8/3.0	11.8/4.4
60	-1.8/-5.7	0.3/-4.2	2.3/-2.7	3.8/-1.7	5.9/-0.2	8.5/1.7	10.5/3.1
70	-3.1/-7.0	-1.0/-5.5	1.1/-4.0	2.5/-3.0	4.6/-1.5	7.2/0.4	9.2/1.9
80	-4.4/-8.3	-2.3/-6.8	-0.2/-5.3	1.3/-4.2	3.3/-2.7	5.9/-0.9	8.0/0.6
90	-5.6/-9.5	-3.5/-8.0	-1.5/-6.5	0.0/-5.5	2.1/-4.0	4.7/-2.1	6.7/-0.7
100	-6.9/-10.8	-4.8/-9.3	-2.7/-7.8	-1.2/-6.7	0.8/-5.3	3.4/-3.4	5.5/-1.9

TABLE 7 URBAN FACTOR WITH HATA HEIGHT GAIN CONSIDERATIONS Transmitter Antenna Height 500 m Receiver Antenna Heights 6 m/9 m							
D (km)	66 MHz	100 MHz	150 MHz	200 MHz	300 MHz	500 MHz	760 MHz
10	0.6/-3.3	2.7/-1.8	4.7/-0.3	6.2/0.7	8.3/2.2	10.9/4.0	12.9/5.5
20	-1.4/-5.3	0.7/-3.8	2.7/-2.3	4.2/-1.3	6.3/0.2	8.9/2.1	10.9/3.5
30	-3.1/-7.0	-1.0/-5.5	1.1/-4.0	2.5/-2.9	4.6/-1.5	7.2/0.4	9.3/1.9
40	-4.6/-8.5	-2.5/-7.0	-0.4/-5.5	1.0/-4.5	3.1/-3.0	5.7/-1.1	7.7/0.4
50	-6.1/-10.0	-4.0/-8.5	-1.9/-7.0	-0.4/-5.9	1.6/-4.4	4.2/-2.6	6.3/-1.1
60	-7.5/-11.4	-5.4/-9.9	-3.3/-8.4	-1.8/-7.3	0.2/-5.9	2.8/-4.0	4.9/-2.5
70	-8.8/-12.8	-6.7/-11.2	-4.7/-9.8	-3.2/-8.7	-1.2/-7.2	1.4/-5.4	3.5/-3.9
80	-10.2/-14.1	-8.1/-12.6	-6.0/-11.1	-4.6/-10.1	-2.5/-8.6	0.1/-6.7	2.2/-5.2
90	-11.5/-15.4	-9.4/-13.9	-7.4/-12.4	-5.9/-11.4	-3.8/-9.9	-1.2/-8.0	0.8/-6.6
100	-12.9/-16.8	-10.7/-15.2	-8.7/-13.8	-7.2/-12.7	-5.2/-11.2	-2.6/-9.4	-0.5/-7.9